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Behavioral and social factors influencing open waste burning in Dhulikhel Municipality, Nepal: A qualitative study

Jeevan Prakash Katel* [a] and Khagendra Acharya [b]

[a]Department of Environmental Science & Engineering, Kathmandu University, Nepal.
[b]Department of Management, Informatics & Communication, Kathmandu University, Nepal.

Abstract

Open Waste Burning (OWB) is a solid waste management problem in developing countries, resulting into serious environmental and health concerns. Although an increasing number of literature focuses on estimating emissions, signifying the state of the problem, and assessing the environmental and health risks; the factors affecting open waste burning, specifically the underlying behavioral factors remain less studied. In this paper, we take a qualitative approach to study social and behavioral factors affecting open waste burning in Dhulikhel, a suburban municipality in Nepal. An in-depth semi-structured interview of seven people directly engaged in OWB practices was taken, and the obtained data was analyzed inductively to construct themes. Waste accumulation, adjustment to recent provision of waste collection service, and its convenience and accessibility are key factors that explain the close connection of waste management practices to OWB. Lack of scientific and complete awareness, lesser knowledge of environmental risks, seeing OWB as an "infrequent exception", and a negative perception of one's community were found to increase OWB incidence. Other factors identified include increasing plastic waste, distinct nature of agriculture waste, and influence of infrastructural barriers. Context-specific qualitative exploration undertaken in this study confirms some pre-identified factors and identifies three distinct social and behavioral factors, establishing a baseline for future assessments.

Keywords: Behavioral factors; Community perception; Open waste burning; Qualitative study; Solid waste management.

1. Introduction

Municipal solid waste management is a pressing problem in developing countries like Nepal, which rises with increasing population in urban and suburban areas [1, 2, 3]. Open Waste Burning (OWB) is a global solid waste management problem because of the fact that one-third of the total solid waste generated worldwide is not collected, and an estimated 42% of the generated solid waste goes through dumping or burning in the open [4].

The phenomenon of OWB involves burning waste produced in houses or residential areas, in the neighborhood spaces or in nearby public areas, setting discarded garbage on streets or garbage containers on fire or controlled burning of waste away from residential areas [5]. Although both domestic OWB, and the controlled incineration performed away from cities or residential areas, have their own share of emissions and negative consequences, residential/domestic OWB can be much worse in terms of pollutant emission and exposure to people [6, 7]. About seven million people die prematurely every year due to air pollution [8]. OWB contributes substantially to the emission of some major pollutants, like Particulate Matter (PM), Organic Carbon (OC), and Carbon Monoxide that cause air pollution related health issues [9]. Therefore, OWB is an issue that requires severe attention in developing countries with low waste collection, high OWB incidences, and higher risk of air pollution related health problems [9, 10, 11].

In Nepal, solid waste management is poor and thus there are practices such as open dumping of waste in rivers and public places, and open burning [12]. The solid waste composition of municipalities in Nepal is reported to be high in organic waste, at about 54%. About 33% is constituted by inorganic waste, with 13% other materials [13]. A 2013 report estimated that about 38% of the generated solid waste in Nepalese municipalities goes uncollected [14]. In developing countries like Nepal, the final method of disposal for this uncollected waste, especially combustible wastes, is open burning [11, 15]. In Kathmandu Valley, the estimated Municipal Solid Waste (MSW) burning was reported to be 3% of the total waste generated, three-fold more than the government estimates [16]. The same study revealed that OWB incidences are more common in suburban areas. Scholarly studies on OWB are limited and are still in early stages, and gaps related to health and environmental risks, differing characteristics of OWB with waste composition, and factors affecting OWB practices can be identified in literature [16].

The Solid Waste Management act of Nepal (2011) designates the responsibility of waste collection, disposal and overall management to the local level government, or the municipalities. Thus, the regulations regarding OWB are specific to each municipality, with some of them, for instance, Kathmandu Municipality, imposing a ban. In 2018, the Supreme Court of Nepal imposed a ban on OWB within the Kathmandu Valley due to extreme air pollution [17]. However, a federal regulatory provision for OWB is still to be formulated. And, most municipalities, including Dhulikhel, which is the site of this study, suffer from lack of clarity in OWB policies, and hence they have poor waste collection efficiency [14, 15, 18].

The prevalence of OWB is higher in semi urban areas because of higher waste generation compared to rural areas, and a greater availability of spaces to burn compared to urban areas [5, 16]. Although the contribution of OWB to the total anthropogenic emissions was estimated only to be 5% of the total global anthropogenic emission of 2010, most of the emissions are concentrated in devel-

*Corresponding author. Email: jk07061720@student.ku.edu.np

oping countries [9, 19, 20]. The contribution of OWB to other pollutants, such as PM2.5, particulate organic carbon (OC), and Carbon Monoxide (CO), is found to be significantly more. For example, the estimated PM2.5 and the particulate organic carbon (OC) emissions from OWB are 29% and 43% of the total global anthropogenic emissions, respectively [9]. The composition of waste, and consequently the emissions from OWB vary with factors such as income levels, seasons, and the level of development of the country [21, 22, 23]. While there is variation in waste composition and production, globally solid waste production and the proportion of plastic waste has increased simultaneously, a significant proportion of which goes through OWB for disposal in developing countries [24, 25].

Most studies point out infrastructural provisions for waste pickup as the major factor affecting OWB [9, 26, 27]. However, OWB occurs also in places where waste collection services are available [27, 28]. Another widely mentioned reason behind OWB is the knowledge and awareness of negative environmental and health effects [27, 28, 29, 30]. Other factors include convenience and cost, lack of incentives for proper management, absence of regulation, getting rid of smells and insects, insufficient space, large amounts of waste produced in certain events, and constraints of local government [30]. A study focusing on the social and infrastructural factors related to OWB in three Delhi neighborhoods reports "burning MSW for warmth", "awareness of regulations", and "cultural beliefs" as the factors, outside the ones usually mentioned [28, 30]. This reveals that the factors affecting OWB can be distinct with the socio-behavioral context and these underlying elements are important to understand broad reasons, such as "infrastructure deficit". In another study, the respondents are reported to believe that people also burn waste out of habit and are not patient to wait for the collection services [27]. The studies on factors affecting OWB practices and the numerous underlying behavioral elements, however, remain understudied in domestic OWB studies. A recent review of domestic OWB clearly points out that the analysis of factors motivating people to engage in OWB is underrepresented in the literature and recommends behavioral studies [30]. The limitation of literature focusing specifically on the factors causing OWB has also been reported in other studies [16, 28].

In this study, we examined, using a qualitative approach, the social and behavioral factors affecting OWB practices in Dhulikhel, a Nepalese sub-urban municipality. The study of the behavioral factors is often complex as they are tied with social, infrastructural, psychological and various other factors. Therefore, to study these factors, people's knowledge and perceptions of OWB, its risks, and possible inadequacies of the infrastructure were examined through qualitative study. Also, specifically for behavioral factors, past and present daily waste management practices, perception of community's waste management, and personal opinions of engagement in OWB were inquired.

2. Materials and methods

The social and behavioral factors that affect OWB practices in the study area were examined using an inductive qualitative approach. The qualitative approach of the study was considered appropriate to identify distinct factors specific to the social context of the study area [31, 32]. It was assumed that the behavioral reasons are connected with people's personal experiences which are better understood empirically. The usefulness of qualitative approach is also stated in its ability to connect environmental problems with the lived experiences of people and environmental policies [33].

2.1. Study area

The study area is Dhulikhel Municipality (shown in Fig. 1), a sub-urban municipality located about 30-km southeast of Kathmandu, the capital of Nepal. As a sub-urban municipality with limited domestic waste collection, OWB is a prevalent practice in Dhulikhel [18]. Despite having a lesser vehicular influence, the high PM 2.5 concentration with significant Organic Carbon (OC) in this city implies that OWB has significant influences on air quality, with OWB contributing up to 30% of PM2.5 OC in 24-hrs measurement in January and February of 2018 [34]. The combination of urban and rural populations has made waste management a challenging task, and the fact that there is prevalence of open waste burning provided a relevant context for the study of behavioral and social factors.

In addition, the survey locations in the study area are susceptible to periodic flooding and transport of solid waste to and from nearby areas. Dhulikhel Municipality has imposed an informal ban on open dumping of waste in public areas which is announced through waste collection vehicles. However, open dumping of solid waste in riverbanks is a fairly common practice and the lack of infrastructural provisions to prevent such practice adds to the solid waste management problem, especially during the seasons when waste pickup is unreliable.

2.2. Sampling and data collection

Purposive sampling, based on observation of people engaged or admitted to engage in OWB practices, was used to select the participants. This allowed the selection of information rich and relevant samples to capture the complexity of the phenomenon being studied in detail [35]. The selection of sample size was determined based on the criteria of data sufficiency. Each sample was added till the views expressed by them provided insights to new behavioral elements [36, 37].

Semi-structured interviews were carried out to explore the behavioral and social factors affecting OWB practices in this study. An interview-protocol was designed, based on an accepted framework including factors mentioned in existing literature, and questions exploring understudied behavioral elements underlying the different factors [38]. The design of the interview protocol was initially based on existing literature review and further revisions were made after piloting and subsequent consultation with disciplinary experts. Homogeneity of the sample was ensured involving participants from similar age, household income, and education level.

The interview protocol was used flexibly, without expressing any implicit judgment on OWB, and frequently updated during the course of data collection to explore additional factors, and exclude questions that repeated ideas, or made interviewees uncomfortable. Ethical considerations such as confidentiality, anonymity, voluntary participation, and option to withdraw were insured in all interviews. The interviews were taken in the span of three months from September to November.

2.3. Data analysis

The six-step process of thematic analysis was used for analyzing the obtained data [39]. The interview recordings were listened to and transcribed verbatim. After familiarization with the data, notes were added for insights of patterns in data. The transcribed interviews were uploaded to Taguette V1.4.1 and initial codes were generated. Taguette is a widely-used, open access, and collaborative qualitative data analysis software used for arranging interviews, discussions, and texts into structured codes in qualitative research [40, 41, 42, 43]. However, it is only semi-assistive requiring full user effort and cognition to extract meaningful themes through similar sections of code from provided texts [44]. The

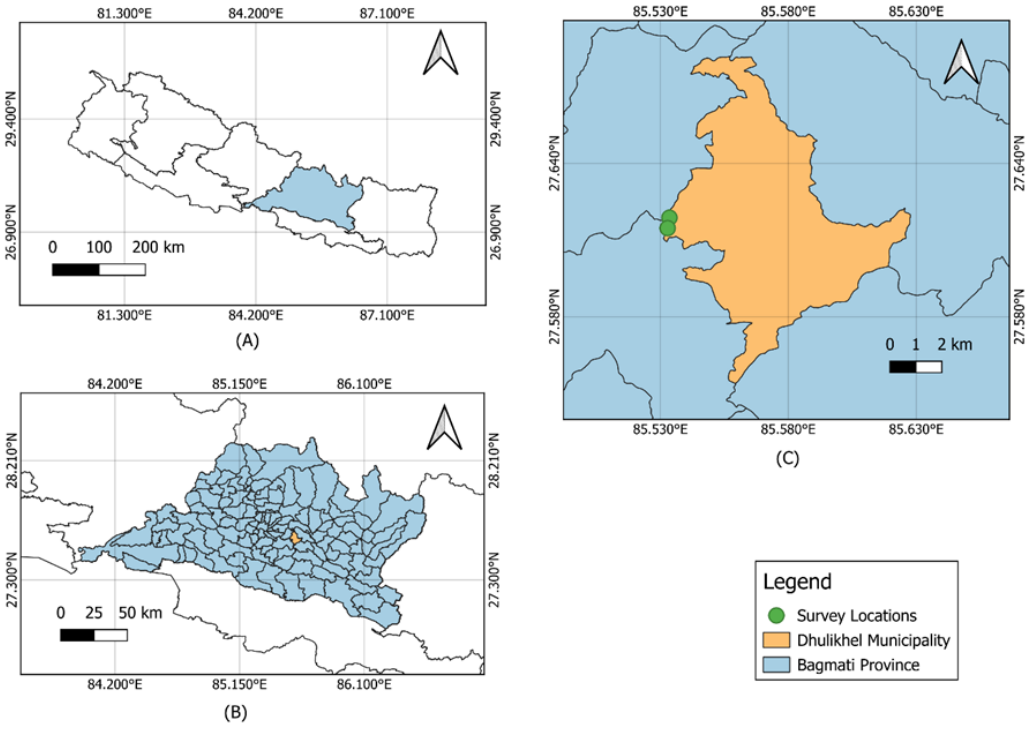

Figure 1: Study area map; (A) Political map of Nepal with Bagmati (highlighted) and other provinces (B) Dhulikhel Municipality in Bagmati province; (C) Two survey locations within Dhulikhel Municipality.

entire interviews were coded broadly to encompass the variety of data generated. Themes were synthesized from the codes and were revised, separated, combined and reviewed multiple times based on dual-criteria judging [45]. At last, these themes were named, subdivided for comprehensibility, and extracts from interviews capturing the essence of the themes were quoted along with the themes.

3. Results and discussions

The themes constructed from the analysis and codes included within each theme are outlined in Fig. 2. Six major themes were identified with codes under "Waste Management Practices" occurring most frequently followed successively by "Incomplete Awareness", "Perception Towards the Community", "Infrastructural Barriers", "Increased Plastic Use in Recent Times", and "Agricultural Waste". Among the themes presented in findings, waste management practices, awareness and agricultural waste, as factors related to OWB have been discussed previously [26, 28, 30]. However, the study here also further explored underlying behavioral and other elements within these factors.

3.1. Waste management practices

Certain behavioral practices used by people to manage wastes in their daily lives were found to lead to OWB practices. The construction of the theme is based on 5 categories: "Waste Management Practices", "Waste Collection Services", "Waste Accumulation", "Cases of Engagement in OWB" and "Overall Infrastructure." We found that people can still engage in OWB despite reporting satisfaction with the waste collection services. Waste accumulation is a key behavioral aspect in that regard, where burning is done to get rid of the negative consequences of waste accumulation.

- Interviewee 5: If the waste collection vehicle comes in timely, we give away the waste. In case the service is not available timely, and the waste becomes a lot, we select to burn it. There is no space to keep the collection of a lot of plastics ... If the municipal waste collection service is not available for many days, we burn the plastic waste and dump the remaining waste into rivers. I don't like keeping waste, so I choose to dispose of it.
- Interviewee 3: I prefer to give the collected waste to the collection vehicle, but second to that, I'd choose to burn it. There are more chances of diseases spreading if the waste gets accumulated.

Participants of the study were provided with municipal waste collection services only in recent years. Previously, OWB used to be a major disposal method for non-degradable flammable wastes. Adjusting to a different waste management practice has different underlying issues which encouraged OWB, such as unavailability of waste collection services in some streets, or during some periods of time, and unsuited timing collection. As stated by interviewee 3, "The waste collection service started 2–3 years ago here. Everyone used to burn their waste before that."

While most participants found burning waste easier, some preferred giving it to the collection vehicle. People are likely to engage in OWB when the convenience and availability of waste collection services are affected by physical infrastructure like road availability, the distance between the house and the nearby road where the collection vehicle comes, and the availability of collection places.

- Interviewee 3: Burning plastic causes diseases, so it should be handed to the waste collection. It is easier to give away the waste to collection services ... We have to carry our collected waste and go up (to the place where the vehicle comes). It doesn't come up here. It would be easier if they came to the house or allocated a place where we could accumulate the wastes.

This reaffirms that the daily waste management practices of house-

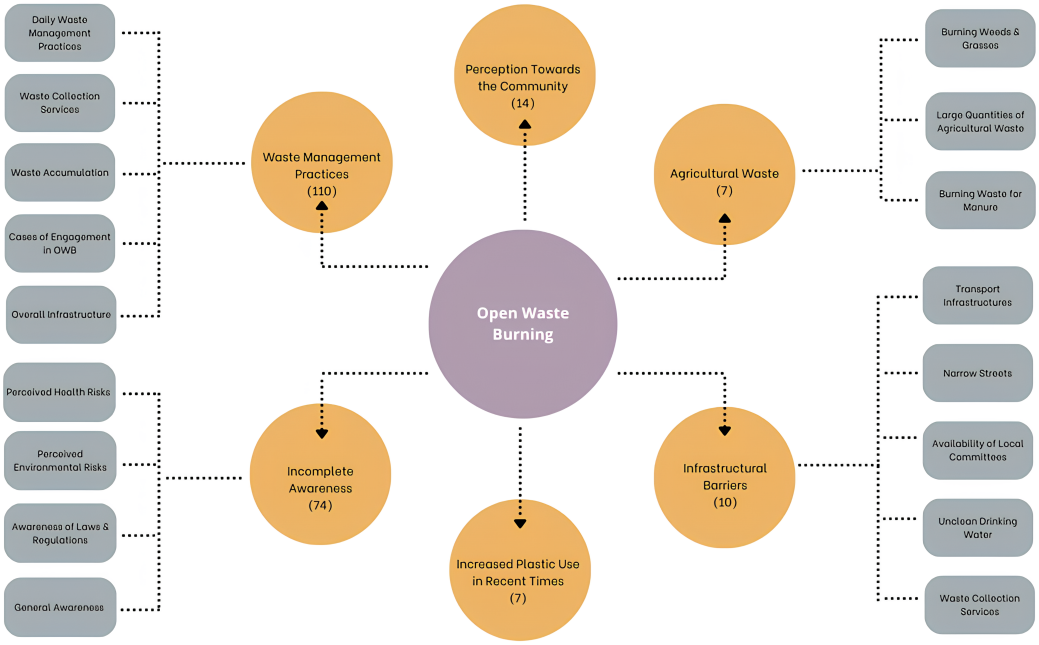

Figure 2: Themes and included codes representing identified factors related to open waste burning from analysis. The numbers below the themes are the total number of code occurrences related to each theme.

holds are among the most influential factors affecting OWB and its frequency [30]. Within the current waste management practices, we find that people's perspective towards the problems posed by waste accumulation is a key behavioral element, and that OWB is taken as an instrument to solve the problems caused by waste accumulation. Similar to this, 'preventing waste accumulation' and 'waste collection frequency' were reported previously as a prominent factor on why people chose to burn waste [16, 28].

Infrequent or unavailable waste pickup has been outlined by numerous studies as a key reason behind OWB [9, 26, 27]. By further exploration of this factor, we outline two additional elements within the theme "Waste Management Practices" that can significantly affect waste pickup: behavioral adjustment to recently provided waste collection service, and the convenience & accessibility of waste collection services. Even in areas where waste collection service is provided these behavioral elements, like unavailability of pickup in some streets, unsuited timing, road availability, availability of collection places, can hinder waste collection efficiency, and therefore lead to OWB. This finding supports the report of a higher fraction of waste burned in areas with inaccessible, and difficult roads, within Kathmandu Valley [16].

3.2. Incomplete awareness

This theme is constituted by the interview parts reflecting the interviewees' awareness in three aspects, environment, health, and laws & regulations. The codes included in this theme are "General Awareness", "Perceived Health Risks", "Perceived Environmental Risks", and "Awareness of Laws and regulations."

Although most interviewees were aware that OWB has negative impacts, interviewees' knowledge regarding the waste and OWB itself was found either less comprehensive, or some less-scientific thoughts were found to be associated with it.Most of the responses on awareness were only limited to knowing that waste should not be burned. Interviewees provided answers to some of the diseases they had heard to be caused by OWB such as respiratory diseases, headaches, cancer, etc., whereas only two interviewees reported on the environmental effects. This was limited to knowing that OWB is 'unhygienic', causes pollution, and waste should not be burned close to home. All the interviewees also reported that there had not been any information or awareness programs on waste management in general.

Interviewee 1: The smoke from burning wood during rituals doesn't affect health. People have been used to inhaling the smoke from wood since early times ... Even plastic starts decomposing after 1–2 years.

- Interviewee 3: Only plastic waste should be burned, but degradable waste should be composted ... I am not aware of any such (environmental and health) risks.

Awareness of health and environmental risks is another often-described factor in relevant literature [26, 28, 30]. However, our findings suggest that despite being aware of OWB's negative health consequences, people still engage in it due to a less complete, or unscientific understanding of the topic. A similar finding has been reported before of limited awareness of health risk that is inadequate to restrict OWB [28]. Additionally, we also discovered that awareness of environmental risks was almost completely absent compared to the awareness of health risks, where interviewees discussed several health risks voluntarily.

3.3. Perception towards the community

This theme is constructed from a single code derived from the behavioral section of the interview, which included inquiries on how people handled waste in their daily lives, why they thought OWB was practiced in their community, their opinions on OWB, etc. While community waste management practices were found to have both similarities and differences among different members, most interviewees believed that people in their community had a similar approach to waste management as themselves. Another common belief was that OWB was an infrequent practice, being only an exception.

Two interviewees, whose ideas are presented below, viewed their community as unhygienic, showing some ethnic bias.

- Interviewee 1: Settlements with a "specific" community are less hygienic and produce more waste. We're less likely to throw away waste randomly by culture.
- Interviewee 3: Our locality is very unhygienic. I don't know why, but no one cares about cleanliness. I prefer to give the

collected waste to the collection vehicle, but second to that, I'd choose to burn it.

Both these excerpts allege certain ethnic group as the cause of OWB. This is a serious issue and thus demands an appropriate attention.

3.4. Agricultural waste

Agricultural waste is the the unwanted or leftover materials produced from agricultural activities such as cropping, livestock farming, or agricultural industries [46]. These wastes are usually generated in large quantities and can include both solid and liquid forms, such as crop residues, manure, and harvest waste [47]. Agricultural waste poses challenges different from domestic waste, such as long duration of time taken for decomposition, large quantities to be handed over to the collection service, and it can be quickly converted into ashes to use as manure by burning. As a consequence, these wastes are collected and managed on the farmlands by burning. This theme comprised categories such as burning weed and grasses, large quantities of agricultural waste, manure by burning waste, etc. with a total of 7 occurrences.

- Interviewee 2: Sometimes people do burn waste, especially agricultural residuals like hays, corn husks, because you can't dispose of them anywhere ... When we have such agricultural residues or dried grasses, etc. When they are more than what can be decomposed, we decide to burn them ... Agricultural waste is difficult to dispose of, but people can still choose to decompose if it can be managed that way. We also have a piece of land and sometimes there is no other option.

Agricultural wastes are a major category of waste dealt with by OWB and have been abundantly represented in the literature [30, 48]. Some behavioral elements within agricultural waste burning are reported in the present study: *long periods of time taken to decompose agricultural waste, waste in quantities too large to be handed over to the collection service, and quick and easy formation of ashes from OWB, used as manure.*

3.5. Increased plastic use in recent times

Interviewees noted the increased use of plastic in recent times as they reflected upon waste management differences in the past and present. All the interviewees responded that they have only dealt with plastic waste in recent times. Since plastics are the major category of domestic waste burned, the increased availability and use of plastics in recent times might be related with OWB occurrences.

- Interviewee 3: The use of plastics is increasing every day compared to before. They weren't available before and started being available later. Everything is carried in plastics nowadays. If you carry a bag while shopping, it can decrease the amount of plastic waste.
- Interviewee 4: In my earlier location, people composted in their fields. They had farms and animals and waste could be composted along with the manures. When I used to live there, there used to be no such thing as plastic.

The above statements present recent phenomenon of increased plastic use as the cause of OWB. Clearly, this reality demands the concerned authorities to pay attention to the possibilities of any new product's adverse impact before granting approval.

3.6. Infrastructure barriers

OWB practices were found to be influenced by the unavailability of infrastructures, even the ones not directly linked with waste management, such as drainage, road conditions, drinking water, public collection places, etc. Although "infrastructural factors" are considered as a major factor affecting OWB, most of the participants' reasons were limited to the availability of waste collection services. People are less likely to be worried of the impacts of OWB practices when they are already troubled by the quality and quantity of water, drainage, roads, etc. The codes included within this theme are "Waste Collection Services", "Narrow Streets", "Ward Committees", "Unclean Drinking Water", and "Transport Infrastructures."

- Interviewee 1: There aren't any waste collection services here. We haven't been able to form a committee here. Because the street is narrow, the collection vehicle cannot enter. The streets are flooded during the summer. There is neither a road here (she means a road wide enough for the vehicle) nor sewerage. Drinking water is only available twice a week, and the water from the well is unclean. Even though we're Brahmins, we cannot get clean water regularly in the morning for "Poojapaath" (cultural morning prayers and rituals). Since we live close to the river, the water in our wells is unclean. The sewer (dirty water from the river) enters our well. We are ready to create a committee and pay for garbage collection, but we are unable to do so because of the road.

The participants' reasons for OWB are not linked to their unwillingness or illiteracy, infrastructural unavailability is stated as the prime cause of OWB. This fact points to the importance of the municipality citizens' access to waste disposal.

Inference from the themes

Most interviewees in our study were aware that waste should not be burned in general and that OWB has negative impacts. The knowledge, however, was found to be less comprehensive when they were posed with environmental, legal and health related questions.

The awareness of diseases related risks of OWB was sound but the awareness of transfer of these risks through environmental pollution was mostly absent. The knowledge regarding OWB and waste management in general was found to be limited, a part of which could be due to the lack of organization of any information or awareness programs, as reported by the interviewees.

A unique factor related to OWB explored in this study are the perceptions that drive people to engage in OWB practices. This includes primarily the view of OWB as an infrequent exception, and community members as unhygienic, influenced by social and ethnic biases.

Some interviewees also associated OWB with uncomfortable or dissatisfactory feelings (expressed to be 'not looking good'). Another common belief among interviewees was that other people in the community had a similar approach to waste management as themselves. Interviewees preferred formal waste collection through vehicles but second to that, OWB was seen as a choice, especially to prevent waste accumulation. In addition, people were also found to be less likely to be worried of the negative impacts of OWB when they were troubled by other infrastructural issues such as water quality/quantity, drainage, and roads.

Daily waste management practices had a frequent connection to OWB as factors, influencing both whether or not, and how often OWB occurs. Waste accumulation, within the current waste management practices, is the key behavioral aspect which explains OWB. People were found to either burn waste or dispose of waste in rivers and streets when waste accumulation occured. Adjusting to a recent waste collection provision was found to have challenges that encourage OWB, such as unavailability of collection in some streets, unsuited timing, and lack of convenient collection places. Even when waste collection was available, convenience and acces-

sibility were two additional factors that could reduce waste collection efficiency, cause accumulation and lead to OWB.

In brief, OWB is taken as a convenient tool to get rid of problems that can be caused by waste accumulation. Special waste types like agricultural and plastic waste were noted by interviewees as distinct and most susceptible to burn, because of their challenges in management.

4. Conclusion and recommendations

Through a qualitative exploration of people's knowledge, experiences, attitudes, and perceptions, we studied the social and behavioral factors affecting OWB practices in a Nepali suburban context. The findings suggest that three key behavioral factors under waste management practices are closely connected to OWB – waste accumulation in streets and in homes, recent provision of waste collection service and its convenience and accessibility. While a general awareness of negative effects of OWB is reported, it is also reported to be surrounded by less comprehensive or less scientific knowledge of waste and burning. Interviewees perceived community waste management as similar to their own, viewed OWB as an infrequent exception, and some also viewed their community as 'unhygienic". The unique challenges posed by agricultural waste makes it susceptible to being dealt by burning. Besides these the increased use of plastic in recent times and the unavailability of infrastructures such as drainage, road conditions, drinking water, etc. also have connection to OWB.

A limitation to be considered with this study is the generalization of this study. While a large sample size can increase generalizability and diversity in data, the essence of qualitative research is understanding the depth of the problem by focusing on singular cases [49, 50]. This concurs with the aim of this study to explore additional behavioral and social factors affecting OWB practices in the study area. Any research that uses an inductive or a 'bottom-up' process to construct a theme comes with the limitation of researchers projecting their "theoretical and epistemological commitments" [39]. The study presented here also is not free of similar biases. To overcome these biases the 'open-endedness' nature of semi-structured interviews were maintained.

Since the study is only aimed to explore the factors, a thorough evaluation of the factors suitable to different contexts can be useful to address the OWB. Waste collection should be made efficient by using waste accumulation as a measure of finding out the optimum waste collection frequency. In addition, it should also be made convenient and accessible by designating public collection sites, placing bins, expanding reach, and extending the duration of stop for collection vehicles where needed. The effect of infrastructural barriers on people's possibility of engaging in OWB practices also requires further investigation.

The "unhygienic" perception towards communities influenced by social and ethnic prejudices also highlights the need to address disparities and use participatory approaches to keep the community clean. For clarifying unscientific beliefs and improving the overall knowledge of waste management, public education through awareness programs is necessary. For agricultural waste management, authorities need to provide services of composting, recycling, or special pickups during certain months where agricultural waste is high. The problems posed by increased plastic waste in recent times need to be addressed by discouragement or informed control, and awareness of plastic use and reuse. This finding also indicates that with the production of new forms of waste such as plastics and e-wastes, awareness in people is necessary beforehand to avoid mismanagement. The increasing use of plastic in agriculture as mulch or cover, and the linkage of it in both agricultural and plastic waste management can be useful topics to explore in further studies.

The limitation of policies only to informal ban in cities such as Dhulikhel, necessitates the urgent need for the local governing bodies to develop clear policies in federal and municipal levels to address OWB. Ineffective waste management services and infrastructural barriers to waste collection require the development of policies that ensure effective, convenient, and accessible waste management services for all residents. The findings on incomplete awareness among people indicates an urgent need of policies to improve the overall knowledge of waste management in people, from a diverse perspective of environment, legislation and health. Education and awareness programs can be effective to educate people of such perspectives and clearly communicate developed policies.

In addition, authorities should also look to improve beyond traditional singular approach of waste collection to 3R (Reduce, Reuse, and Recycle) and 5R (Refuse, Reduce, Reuse, Repurpose and Recycle) principles, which can minimize OWB. Specific policy interventions within these principles can include actions like providing services for composting, setting up and encouraging recycling plants, consumer awareness, imposing ban on single use plastics, etc. The linkage of infrastructural barriers to OWB explored in the study also highlights the importance of policies addressing fundamental urban services in supporting waste management. Addressing community perceptions, including those influenced by social and ethnic biases, also requires policy approaches that improve cooperation and address disparities in the community. Clear communication to public and strict implementation of these policies on ground level can be useful to translate these findings on social and behavioral factors to reduce OWB and improve overall waste management outcomes.

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Data sharing and data availability

The data that support the findings of this study are openly available in Mendeley Data at *https://doi.org/10.17632/7sczrgm4mt.2*.

References

[1] Guerrero L A, Maas G & Hogland W, Solid waste management challenges for cities in developing countries, *Waste Management*, 33(1) (2013) 220–232. ISSN 0956-053X. https://doi.org/10.1016/j.wasman.2012.09.008.

[2] Mmereki D, Baldwin A & Li B, A comparative analysis of solid waste management in developed, developing and lesser developed countries, *Environmental Technology Reviews*, 5(1) (2016) 120–141. ISSN 2162-2523. https://doi.org/10.1080/21622515.2016.1259357.

[3] Pokhrel D & Viraraghavan T, Municipal solid waste management in Nepal: Practices and challenges, *Waste Management*,

25(5) (2005) 555–562. ISSN 0956-053X. https://doi.org/10.1016/j.wasman.2005.01.020.

[4] Maalouf A & Mavropoulos A, Re-assessing global municipal solid waste generation, *Waste Management & Research: The Journal for a Sustainable Circular Economy*, 41(4) (2022) 936–947. ISSN 1096-3669. https://doi.org/10.1177/0734242x221074116.

[5] Daffi R E, Chaimang A N & Alfa M I, Environmental impact of open burning of municipal solid wastes dumps in parts of jos Metropolis, Nigeria, *Journal of Engineering Research and Reports*, 12 (2020) 30–43. ISSN 2582-2926. https://doi.org/10.9734/jerr/2020/v12i317083.

[6] Gullett B K, Wyrzykowska B, Grandesso E, Touati A, Tabor D G & Ochoa G S, PCDD/F, PBDD/F, and PBDE emissions from open burning of a residential waste dump, *Environmental Science & Technology*, 44(1) (2009) 394–399. ISSN 1520-5851. https://doi.org/10.1021/es902676w.

[7] Krajčovičová J & Eschenroeder A Q, Comparative health risks of domestic waste combustion in urban and rural Slovakia, *Environmental Science & Technology*, 41(19) (2007) 6847–6853. ISSN 1520-5851. https://doi.org/10.1021/es0627186.

[8] World Health Organization. Ambient (outdoor) air pollution. WHO Fact Sheet (2024). URL https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.

[9] Wiedinmyer C, Yokelson R J & Gullett B K, Global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste, *Environmental Science & Technology*, 48(16) (2014) 9523–9530. ISSN 1520-5851. https://doi.org/10.1021/es502250z.

[10] Paranagamage L C, Hayashi M, Ramadan B S, Gamaralalage P J D & Ghosh S K, Nexus of air pollution, climate change and waste: Policy gaps of open waste burning in selected Asian countries, *Journal of Waste Management &Recycling Technology* (2025) 1–6. ISSN 2976-7687. https://doi.org/10.47363/jwmrt/2025(3)143.

[11] Velis C A & Cook E, Mismanagement of plastic waste through open burning with emphasis on the Global South: A systematic review of risks to occupational and public health, *Environmental Science & Technology*, 55(11) (2021) 7186–7207. ISSN 1520-5851. https://doi.org/10.1021/acs.est.0c08536.

[12] Alam R, Chowdhury M, Hasan G, Karanjit B & Shrestha L, Generation, storage, collection and transportation of municipal solid waste - A case study in the city of Kathmandu, capital of Nepal, *Waste Management*, 28(6) (2008) 1088–1097. ISSN 0956-053X. https://doi.org/10.1016/j.wasman.2006.12.024.

[13] Central Bureau of Statistics (CBS). *Waste Management Baseline Survey of Nepal 2020,*. Central Bureau of Statistics,Government of Nepal (2023).

[14] Asian Development Bank. *Solid Waste Management in Nepal, Current Status and Policy Recommendation*. Asian Development Bank (2013).

[15] Yadav P & Samadder S R, Environmental impact assessment of municipal solid waste management options using life cycle assessment: A case study, *Environmental Science and Pollution Research*, 25(1) (2017) 838–854. ISSN 1614-7499. https://doi.org/10.1007/s11356-017-0439-7.

[16] Das B, Bhave P V, Sapkota A & Byanju R M, Estimating emissions from open burning of municipal solid waste in municipalities of Nepal, *Waste Management*, 79 (2018) 481–490. ISSN 0956-053X. https://doi.org/10.1016/j.wasman.2018.08.013.

[17] Nepali Times. No smoke without fire in Kathmandu (2022). URL https://nepalitimes.com/here-now/no-smoke-without-fire-in-kathmanduNepaliTimes.

[18] Paudel S & Gyawali M, Environment management plan, *Integrated Urban Development Plan of Dhulikhel Municipality*, 6 (2019) 1–80.

[19] Reyna-Bensusan N, Wilson D C & Smith S R, Uncontrolled burning of solid waste by households in Mexico is a significant contributor to climate change in the country, *Environmental Research*, 163 (2018) 280–288. ISSN 0013-9351. https://doi.org/10.1016/j.envres.2018.01.042.

[20] Venkataraman C, Habib G, Kadamba D, Shrivastava M, Leon J F, Crouzille B, Boucher O & Streets D G, Emissions from open biomass burning in India: Integrating the inventory approach with high-resolution moderate resolution imaging spectroradiometer (MODIS) active-fire and land cover data, *Global Biogeochemical Cycles*, 20(2). ISSN 1944-9224. https://doi.org/10.1029/2005gb002547.

[21] Nagpure A S, Ramaswami A & Russell A, Characterizing the spatial and temporal patterns of open burning of municipal solid waste (MSW) in Indian Cities, *Environmental Science &Technology*, 49(21) (2015) 12904–12912. ISSN 1520-5851. https://doi.org/10.1021/acs.est.5b03243.

[22] Nanda S & Berruti F, Municipal solid waste management and landfilling technologies: A review, *Environmental Chemistry Letters*, 19(2) (2020) 1433–1456. ISSN 1610-3661. https://doi.org/10.1007/s10311-020-01100-y.

[23] Yang N, Damgaard A, Scheutz C, Shao L M & He P J, A comparison of chemical MSW compositional data between China and Denmark, *Journal of Environmental Sciences*, 74 (2018) 1–10. ISSN 1001-0742. https://doi.org/https://doi.org/10.1016/j.jes.2018.02.010.

[24] Coban A, Ertis I F & Cavdaroglu N A, Municipal solid waste management via multi-criteria decision making methods: A case study in Istanbul, Turkey, *Journal of Cleaner Production*, 180 (2018) 159–167. ISSN 0959-6526. https://doi.org/10.1016/j.jclepro.2018.01.130.

[25] Geyer R, Jambeck J R & Law K L, Production, use, and fate of all plastics ever made, *Science Advances*, 3(7). ISSN 2375-2548. https://doi.org/10.1126/sciadv.1700782.

[26] Israel P, People's awareness on effects of open burning of household waste in Kinondoni Municipality, Dar-es-Salaam, *Dar Es Salaam Medical Students' Journal*, 15(1). ISSN 0856-7212. https://doi.org/10.4314/dmsj.v15i1.52494.

[27] Krecl P, de Lima C H, Dal Bosco T C, Targino A C, Hashimoto E M & Oukawa G Y, Open waste burning causes fast and sharp changes in particulate concentrations in peripheral neighborhoods, *Science of The Total Environment*, 765 (2021) 142736. ISSN 0048-9697. https://doi.org/10.1016/j.scitotenv.2020.142736.

[28] Ramaswami A, Baidwan N K & Nagpure A S, Exploring social and infrastructural factors affecting open burning of municipal solid waste (MSW) in Indian cities: A comparative case study of three neighborhoods of Delhi, *Waste Management &Research: The Journal for a Sustainable Circular Economy*, 34(11) (2016) 1164–1172. ISSN 1096-3669. https://doi.org/10.1177/0734242x16659924.

[29] Kumari K, Kumar S, Rajagopal V, Khare A & Kumar R, Emission from open burning of municipal solid waste in India, *Environmental Technology*, 40(17) (2017) 2201–2214. ISSN 1479-487X. https://doi.org/10.1080/09593330.2017.1351489.

[30] Ramadan B S, Rachman I, Ikhlas N, Kurniawan S B, Miftahadi M F & Matsumoto T, A comprehensive review of domestic-open waste burning: Recent trends, methodology comparison, and factors assessment, *Journal of Material Cycles and Waste Management*, 24(5) (2022) 1633–1647. ISSN 1611-8227. https://doi.org/10.1007/s10163-022-01430-9.

[31] Gioia D A, Corley K G & Hamilton A L, Seeking qualitative rigor in inductive research: Notes on the Gioia methodology, *Organizational Research Methods*, 16(1) (2012) 15–31. ISSN 1552-7425. https://doi.org/10.1177/1094428112452151.

[32] Öhman A, Qualitative methodology for rehabilitation research, *Journal of Rehabilitation Medicine*, 37(5) (2005) 273–280. ISSN 1650-1977. https://doi.org/10.1080/16501970510040056.

[33] Macura B, Suškevičs M, Garside R, Hannes K, Rees R & Rodela R, Systematic reviews of qualitative evidence for environmental policy and management: An overview of different methodological options, *Environmental Evidence*, 8(1). ISSN 2047-2382. https://doi.org/10.1186/s13750-019-0168-0.

[34] Islam M R, Li T, Mahata K, Khanal N, Werden B, Giordano M R, Praveen Puppala S, Dhital N B, Gurung A, Saikawa E, Panday A K, Yokelson R J, DeCarlo P F & Stone E A, Wintertime air quality across the Kathmandu Valley, Nepal: Concentration, composition, and sources of fine and coarse particulate matter, *ACS Earth and Space Chemistry*, 6(12) (2022) 2955–2971. ISSN 2472-3452. https://doi.org/10.1021/acsearthspacechem.2c00243.

[35] Coyne I T, Sampling in qualitative research. purposeful and theoretical sampling; merging or clear boundaries?, *Journal of Advanced Nursing*, 26(3) (1997) 623–630. ISSN 1365-2648. https://doi.org/10.1046/j.1365-2648.1997.t01-25-00999.x.

[36] Creswell J W. *Qualitative inquiry and research design: choosing among five approaches*. Sage Publication, Thousand Oaks, CA, 3 edn. (2013).

[37] Creswell J & Creswell J. *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications, Los Angeles,CA, 5th edn. (2018). ISBN 9781506386706. URL https://books.google.com.np/books?id=s4VviswEACAAJ.

[38] Jacob S A & Furgerson S P, Writing interview protocols and conducting interviews: Tips for students new to the field of qualitative research, *The Qualitative Report*, 17(42) (2012) 1–10. URL https://eric.ed.gov/?id=EJ990034.

[39] Braun V & Clarke V, Using thematic analysis in psychology, *Qualitative Research in Psychology*, 3(2) (2006) 77–101. ISSN 1478-0895. https://doi.org/10.1191/1478088706qp063oa.

[40] Rampin R & Rampin V, Taguette: Open-source qualitative data analysis, *Journal of Open Source Software*, 6(68) (2021) 3522. ISSN 2475-9066. https://doi.org/10.21105/joss.03522.

[41] Lambert G, Alos N, Bernier P, Laverdière C, Drummond K, Dahan-Oliel N, Lemay M, Veilleux L N & Kairy D, Patient and parent experiences with group telerehabilitation for child survivors of acute Lymphoblastic Leukemia, *International Journal of Environmental Research and Public Health*, 18(7) (2021) 3610. ISSN 1660-4601. https://doi.org/10.3390/ijerph18073610.

[42] Yap J M, Barat A H & Kiszl P, Civic roles of libraries in combating information disorders in social media: A scoping review, *Education for Information*, 40(1) (2024) 21–44. ISSN 1875-8649. https://doi.org/10.3233/efi-220038.

[43] Coggins S, McCampbell M, Sharma A, Sharma R, Haefele S M, Karki E, Hetherington J, Smith J & Brown B, How have smallholder farmers used digital extension tools? Developer and user voices from Sub-Saharan Africa, South Asia and Southeast Asia, *Global Food Security*, 32 (2022) 100577. ISSN 2211-9124. https://doi.org/10.1016/j.gfs.2021.100577.

[44] Šumak B, Pušnik M, Kožuh I, Šorgo A & Brdnik S, Differences in user perception of artificial intelligence-driven chatbots and traditional tools in qualitative data analysis, *Applied Sciences*, 15(2) (2025) 631. ISSN 2076-3417. https://doi.org/10.3390/app15020631.

[45] Patton M. *Qualitative Research & Evaluation Methods*. SAGE Publications, 2 edn. (2002). ISBN 9780761919711. URL https://books.google.com.np/books?id=FjBw2oi8El4C.

[46] Koul B, Yakoob M & Shah M P, Agricultural waste management strategies for environmental sustainability, *Environmental Research*, 206 (2022) 112285. ISSN 0013-9351. https://doi.org/10.1016/j.envres.2021.112285.

[47] Suruchi Singh A S Pardeep Singh, ed. *Agriculture Waste Management and Bioresource: The Circular Economy Perspective*. Wiley (2022). ISBN 9781119808428. https://doi.org/10.1002/9781119808428.

[48] Pasquini M & Alexander M, Chemical properties of urban waste ash produced by open burning on the Jos Plateau: Implications for agriculture, *Science of The Total Environment*, 319(1–3) (2004) 225–240. ISSN 0048-9697. https://doi.org/10.1016/s0048-9697(03)00434-0.

[49] Daniela R M, Determining the sample size in qualitative research, *International Multidisciplinary Scientific Conferences on the Dialogue between Sciences & Arts, Religion & Education*, 4(4) (2020) 181–187. ISSN 2601-839X. https://doi.org/10.26520/mcdsare.2020.4.181-187.

[50] Sandelowski M, Sample size in qualitative research, *Research in Nursing &Health*, 18(2) (1995) 179–183. ISSN 1098-240X. https://doi.org/10.1002/nur.4770180211.

Table 1: Participants with their age, sex, monthly household income, education level, ethnicity and family occupations.

Participant	Age	Sex	Monthly household income (in Rs.)	Education level	Ethnicity	Family occupations
1	45	Female	Around 31 thousand	School Level	Brahmin	Teaching, Farming
2	57	Female	20 to 30 thousand	None	Newari	Convenient store, Farming
3	56	Female	30 to 50 thousand	Primary School	Newari	Retail Shop, Bank employee
4	66	Male	30 to 50 thousand	School Level	Newari	Retail Shop
5	45	Female	20 to 30 thousand	Primary School	Newari	Farming
6	31	Female	Didn't prefer to answer	None	Tamang	Farming
7	34	Male	30 to 50 thousand	Primary Level	Tharu	Didn't prefer to answer

Appendices

Appendix 1: Table 1 Participants with their age, sex, monthly household income, education level, ethnicity and family occupations.

Appendix 2: The interview protocol

The interview-protocol on this study was developed based on factors mentioned in existing literature and questions exploring novel behavioral elements underlying these many factors. The "Traditional & Cultural Factors" section of the interview borrows some key questions from the literature [28], due to a similar socio-cultural context. The flexibility of semi-structured interviews was ensured by probing with follow-up questions whenever new related factors were mentioned or indicated during the interviews.

Section A: Introduction and demographic

1. Brief Introduction of the Interviewer and the Study
2. Information on how the participants' responses can help the study
3. Assuring confidentiality and anonymity
4. Name
5. Age
6. Gender
7. Education Level
8. Ethnicity
9. Religion
10. Family members
11. Highest Education Level in Family
12. Monthly family income range: low, middle, high (Below 10,000; 10 to 20 thousand; 20 to 30 thousand; 30 to 50 thousand, above 50 thousand)

Section B: General

1. Could you share your knowledge on OWB practices?
2. How do you perceive its positive or negative effects?

Section C: Infrastructural

1. How are the waste collection services in your community? (How effective and regular are the waste collection services)
2. Can you tell us your knowledge of the existing rules and laws related to OWB?
3. How would it be easier for you to correctly dispose of your waste if there were better infrastructures, such as dustbins in the neighborhood, more frequent collection, etc.?

Section D: Traditional and cultural

1. Can you share your perspective on waste and burning in your culture?
2. What is your perception of the ceremonial burning of wood or incense?
3. Do you think OWB have the same qualities as such ceremonial burning of wood or incense? Why or why not?

Section E: Behavioral

1. Could you share your thoughts on how you handle waste disposal in your daily life?
2. How do people in your community dispose of waste? How did they do it in the past? (If the respondents moved to the place from a different location ask about the waste disposal practice in their previous community)
3. Do you think burning waste materials is a common practice in your community? If so, Why do you think people burn waste?
4. When are the times you choose to burn waste if you have to? Why?
5. Do you feel uncomfortable that it won't "look good" while engaging in OWB?
6. What is your personal opinion on OWB? (Convenience, effectiveness, safety)
7. How often do people in your neighborhood engage in OWB? How do you feel about it?

Section F: Perception of risks/awareness (Environmental and health)

1. How do you feel about the waste accumulation in streets and homes? Do you prefer OWB or waste accumulation? Why?
2. Have you ever participated in any initiatives or programs related to waste management and disposal? If so, can you describe them?
3. How do you perceive the risks and consequences of open waste burning for yourself, your family, and your community? Are you aware of the effects of OWB on health and the environment?
4. What measures can be taken to reduce open waste burning in your community?